Amendments to the Specification

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[0048] FIG. ~~9a~~ 9b is a partial perspective view of the embodiment of FIG. 9a, schematically illustrating the assembled components;

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[0056] FIG. 13c is an axial plan view of the hub region of an embodiment of the present invention in schematic illustration, with the hub flange shown in partial cross-section to reveal a crossed orientation between spokes connected thereto, with an angle greater than ~~180 . . .~~ 180 degrees

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between the crossed spokes;

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[0077] FIG. 1 describes the basic configuration of a vehicle wheel, in particular, a bicycle wheel 1 as well as a description of the direction conventions used throughout this disclosure. The hub shell 14 is rotatable about the axle 9 and includes at least two axially spaced hub or outer flanges 16, each of ~~if~~ which include a means for connecting with the spokes 2. The hub flange 16 may be contiguous with the hub shell 14 or it may be separately formed and assembled to the body of the hub shell 14 The spokes are affixed to the hub flange 16 at their first end 4 and extend to attach the rim 8 at their second end 6. The tire 10 is fitted to the outer periphery of the rim 8. The axial direction 92 is any direction parallel with the axis of the axle 9. The radial direction 93 is a direction generally perpendicular to the axial direction 92. The tangential direction 94 is a direction within the plane of the rim 8 and perpendicular to the radial direction 93. The circumferential direction 95 is a cylindrical vector that wraps around the axial direction 92 axis at a given radius. While it is most common for the hub shell 14 to rotate about a fixed axle 9, there are some cases where it is desirable to permit the axle 9 to rotate with the wheel 1 such as the case where the wheel 1 is driven by the

a3 cont axle 9.

a4 [0080] FIG. 3 describes a basic embodiment of the present invention in plan view. The wheel 1 includes spokes 2 that are connected at their second ends 6 to the rim 13 via threaded collars 22. Threaded collars 22 engage the head 34 of the spoke 2 to permit the length of ~~if~~ the spoke 2 to be adjusted to provide for proper spoke 2 tension and also to allow for a removable connection between spoke 2 and rim 8. This connection arrangement is described in further detail in FIGS. 10a-b. The tire 10 is mounted to the rim 8 in the standard manner and the hub shell 14 is rotatable about the axle 9 via the bearings 11, including an outer bearing race 30 that is seated in the bearing bore 7 of the hub flange 16. At their inner end, the spokes 2 are threaded into blind cavities 20 of the hub flange 16, to provide firm anchoring in an arrangement as described in FIGS. 4a-c. For the purposes of using conventional terminology, the term "hub flange" is used to describe a region of the hub shell 14 to which the spokes 2 are joined. While the surface of the hub flange may be raised and flange-like in comparison to other surfaces of the hub shell 14, this is not a requirement for the present invention and the hub flange 16 may indeed be flush or recessed relative to other hub shell surfaces.

a5 [0081] It is easiest to mold or otherwise form or fabricate the individual hub flanges 16 separately and then assemble these hub flanges 16, along with other components as required, to create a complete hub shell 14. This hub shell 14 assembly may be permanent or else it may be removably assembled, allowing the hub flange 16 to be disassembled from the hub shell 14 ~~to~~ for servicing in the field. However, it is also anticipated that the hub shell 14, including a multiple of hub flanges

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16, may be molded or formed together as a unit.

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[0084] For such an engagement, it is preferred that the hub flange 16 is made of a softer material, such as a glass filled nylon, and that the spoke 2 is made of a harder material, such as stainless steel. It is also envisioned that the hub flange 16 may be constructed from a wide range of materials, including lightweight metals such as aluminum or magnesium. The main criteria is that the spoke material must be harder than the hub flange 16 material so that the cavity 20 may be deformed by the spoke 2. The hub flange 16 material surrounding the cavity 20 is thus deformed through either plastic or elastic deformation or, most likely, some combination of the two. With polymers in particular, the flange 16 material surrounding the cavity 20 undergoes both plastic and elastic deformation. The plastic deformation results in the conformed engagement of the cavity 20 to the threaded portion 64 of the spoke while the elastic deformation also adds a gripping action between the cavity 20 and the spoke 2 to prevent unthreading. Although the plasticity of most materials wil increase somewhat at higher temperatures, the present invention does not require a softening or melting of the material surrounding the cavity 20 to achieve this deformation. As shown here, the material surrounding the cavity 20 exhibits "cold flow" where it deforms to conform, at least partially, to the contour of the spoke 2 while this material remains in a solid state. Several ~~polymer~~ polymeric materials from the family of crystalline and semi-crystalline thermoplastics are especially well suited for this type of application since they generally have an inherent lubricity to aid in the deforming insertion of the spoke.

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[0096] As opposed to the previous figures, FIG. 8a shows cavities 20 to be non-aligned with the

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span of spoke 2 between the hub flange 16 and the rim 8. As shown, the spoke 2 must now include a bent region 12 external to engaged ~~region~~ portion 18 in order to redirect the spoke span toward its attachment point at the rim (not shown). While this is a less desirable arrangement, since the bend introduces a flex point and a region of higher stress to the spoke, the axial orientation of the cavities 20 makes them easier to form in a mold. The hub flange 16 of this figure may be molded in a simple straight-pull mold configuration since all of the cavities 20 are shown here to be parallel. In the case where the hub flange is fabricated instead of molded, the cavities 20 may now be drilled in a single fixed set-up using standard machine tools. Also shown is axle 9 and bearing 11. The hub flange 16 also includes a reinforcement element or guiding geometry 81 to contact and support the bent region 12 of spoke 2 to reduce any flex due to spoke tension forces 5. This figure also shows a reinforcement ring 84 that is located to surround the outer circumference of the hub flange 16 and support the hub flange 16 in resisting the radial stress imparted by the spoke tension forces 5. The reinforcement ring 84 may also be positioned to contact and support the spoke 2. As shown here, it is intended that the reinforcement ring 84 also serve as a flange spacer to join two opposed hub flanges in a manner similar to hub flange spacer 190 of FIG. 15a. It should also be noted that, rather than circumscribing the outside surface of the hub flange as shown here, the reinforcement ring 84 may alternatively be concealed to reside within the material of the hub flange 16. It should be noted that such a reinforcement element, either external or concealed, may be incorporated into many of the embodiments of the present invention.

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[0104] FIG. 13a shows a radial spoke lacing pattern where the spokes 2 extend radially outward from the hub flange 16 to the rim (not shown). This type of spoke lacing, as opposed to oblique

spoke lacing, results in exceptionally large radial stress and expansion of the hub flange 16 due to spoke tensile loads 5. In this case, there is no spoke crossover in the engaged ~~region~~ portion 18 an , as compared to FIGS. 14a-b, there is a relatively large gap 170 of hub flange 16 material between adjacent spokes 2. Particularly with polymer hub flange 16 material, this gap 170 between spokes can lead to increased material creep and elastic deflection. Even if the stresses in the hub flange 16 material are low enough not to permanently deform the hub flange 16, the spoke loads may cause the hub flange 16 to increase in size and the bearing bore 7 to increase in diameter. These are undesirable characteristics and require that a hub flange 16 of this type be made from a higher stiffness material and/or employ a greater flange cross-section dimension. The result is increased weight and cost as compared to the embodiment of FIGS. 14a-b.

[0105] FIG. 13b shows the crossover region 172 of two of the spokes 2 of the hub flange 16. These two spokes 2 extend in their ~~encapsulated regions~~ engaged portions 18 to cross very close to each other with a relatively small gap of hub flange 16 material therebetween as compared to gap 170 of FIG. 13a. The amount of hub flange 16 material between adjacent spokes 2 is reduced to the minimal axial gap at the crossover 172. While this is an improvement over the embodiment of FIG. 13a, this arrangement, with an acute angle 176 between the two crossing spokes 2 (as measured outward from the axle), still results in a radially outward resultant force 174 imparted to the hub flange 16 due to spoke tension forces 5. This radial resultant force 174 imparts hoop and radial stress in the hub flange 16 material. As the angle 176 between the two spokes 2 is increased, the resulting radial resultant force 174 is reduced, as is the associated hoop stress in the hub flange 16. It should be noted that the engaged portion 18 of the spokes 2 grip the hub flange 16 material along

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the length of the knurled portion 36 of the spoke 2.

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[0106] As angle 176 approaches ~~180 . . .~~ 180 degrees, the spoke tensile forces 5 pull in directly opposed directions and therefore the radial resultant force 174 approaches zero. FIG. 13c shows th angle 176 increased to greater than ~~180 . . .~~ 180 degrees (as measured outward from the axle), which now serves to impart a small radially inward resultant force 178. As shown in FIG. 13c, thr such spoke pairs each provide a radially inward force 178 due to spoke tensile forces 5. The result three equally spaced radial resultant forces 178, which together apply a radially inward compressiv load on the hub flange 16. While most polymer hub flange materials will likely resist this load, it should be noted that a bearing 11 with a hard steel outer race 30 is located in the center of the hub flange 16, inward from the spokes 2. In addition to bearing function duties, the steel outer race 30 also provides support to the hub flange 16 to resist the radial loads 178 induced by the spokes 2 an to prevent the hub flange 16 from deforming. It can be seen that these radial forces 178 induce the bearing bore 7 of the hub flange 16 to shrink and grip the outer bearing race 30, creating a firm fitment between the two parts.

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[0107] While FIG. 13a shows a radially extending engaged ~~region~~ portion 18, in order for the length of engagement 186 to be sufficient to achieve a firm connection, the hub flange 16 must hav a relatively large radial width. While this is often easy to achieve, it is usually preferable to employ an oblique or tangential spoke lacing arrangement, as is shown in FIGS. 13b-c, where the engaged portion 18 of the spoke 2 extends within the hub flange 16 in a generally tangential orientation that is offset from the axial centerline of the wheel, thereby allowing for a more compact hub flange 16

To achieve this, it is preferable that the spoke extends, in its engagement within the hub flange, to a point beyond an imaginary radial line 180 extending from the center of the hub flange 16 in a direction perpendicular to the spoke as shown in FIG. 13d. This depth of engagement in oblique lacing provides a firm connection between the spoke 2 and hub flange 16 and also results in close proximity or overlap with other spokes (not shown) anchored within the same hub flange 16. Thus in the embodiments described herein, it is advantageous to have a longitudinal depth of engagement at least to this imaginary radial line 180 as shown. Dimension 181 shows that, in oblique spoke lacing, the longitudinal axis 184 of the spoke 2 span is offset from the central axis 183 of the axle. Note also that the cavity 20 includes a longitudinal axis that is collinear with the longitudinal axis 184 of the spoke 2 span.

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[0109] By locating the spokes 2 within the hub flange 16 such that they overlap or otherwise maintain close proximity to other spokes, the span of weaker hub flange material between the ~~encapsulated~~ engaged portions 18 of these spokes is reduced. This serves to stiffen the connection between these spokes, since the short span of flexible hub flange 16 material has less overall stretch than a longer span. In addition, as the spokes are brought closer to each other, the interconnecting hub flange 16 material experiences a higher level of shear stress and a lower level of tensile stress. This also contributes to the strength of the connection between the spokes. Thus, with a reduced span of hub flange material between spokes 2 connected thereto, spoke tensile forces 5 are transmitted more directly from one spoke 2 to its neighbor. This tends to reduce the stresses in the hub flange 16 material outside the region of the reduced span. The geometry of the hub flange 16 may now be optimized to provide higher strength and stiffness in the region surrounding this

A12 cont overlap.

A13 [0110] With a longitudinal engagement region, as described previously, the spoke may serve to support and reinforce the hub flange material along the length of this engagement region. Further, if a given spoke crosses two or more spokes within the hub flange 16 material, the spoke then serves as a strengthening bridge to reinforce the hub flange 16 material between these two other crossing spokes. This is well illustrated in FIG. 14b, where one spoke 144 has knurling to grip the hub flange 16 material along the length of its engaged ~~region~~ portion 18 and is shown to be arranged to cross over three other spokes 146, 148 and 160 within the hub flange 16 material. FIG. 14b is actually a detail, showing only the spokes 144, 146, 148 and 160 of FIG. 14a to more clearly illustrate the crossover locations associated with this one individual selected spoke 144. Thus, it may be seen that spoke 144 crosses spoke 146 at crossover region 154 and also crosses spoke 148 at crossover region 156 and also crosses spoke 160 at crossover region 162. In FIG. 14a, a series of twelve spokes are shown to each extend to overlap with three neighboring spokes to create a full circumference of bridged spokes within the hub flange 16. In this way, the engaged portion 18 of the spoke 2 functions to reinforce the hub flange 16 very much like rebar serves to reinforce cast concrete. Thus, the ~~encapsulated~~ engaged portions of these spokes provide radial and hoop strength reinforcement to the hub flange 16 as well as transmitting spoke tensile loads 5 more directly to adjoining spokes, thereby transferring less of the related stress to the weaker hub flange 16 material.

A14 [0113] If we view the complete hub shell 14 as including two axially spaced hub flanges with a spacer element to axially separate the hub flange, the ~~. The~~ hub flanges and spacer(s) constitute the

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rotatable hub shell 14. FIG. 15a describes an embodiment that includes a separate cylindrical hub flange spacer 190 component to axially space the two outer hub flanges 16a and 16b in their desired separation dimension. In FIG. 15a, the hub flanges 16a and 16b each include a collar 192 that extends axially as shown. The outside surface 194 of the collar 192 of each hub flange is inserted into the inside surface 196 of their respective ends of the flange spacer 190. Adhesive is added to this sleeved joint in the gap between the surfaces 194 and 196 to firmly connect the components together. Other joining methods may be employed instead of, or in addition to, the adhesive, such as snap fits, press fits, fasteners, etc. Additionally, in the absence of a fastening system, the spoke tension forces may be utilized to force the hub flanges 16a and 16b axially toward each other to sandwich and retain the spacer 190. It is further envisioned that the spacer 190 may be incorporated within hub flange 16a as a single component. There would then be only one joining connection required between hub flange 16b and spacer 190.

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[0127] FIG. 20 describes an embodiment similar to FIG. 17c, where hub flange 16 includes an open cavity 133. Clamping member 96 ~~is~~ includes open cavities 135 and serves to sandwich and clamp the spoke 2 between the hub flange 16 and the clamping member 96. In contrast to FIG. 17a, the surface of both the cavities 133 and the cavities 135 have a configured interior surface in the form of raised ribs 136. Spoke 2 has a smooth end 4 and is generally of softer material than the material of both the hub flange 16 and the clamping member 96. One candidate spoke material for this embodiment is a composite spoke 2 formed from polymer resin with longitudinal synthetic fiber reinforcement. Clamping member 96 includes open cavities 135 that are aligned to be directly opposed to cavities 133 of the hub flange 16. In assembly, spokes 2 are first positioned such that

ends 4 are nested in their corresponding cavities 133. Clamping member 96 is then assembled to axially sandwich the ends 4 of spokes 2, which are also nested also in their corresponding cavities 135. Screw 97 is passed through clearance hole 100 and threaded into the hub flange 16. When the screw 97 is tightened into hub flange 16, with its screw head pressed against the clamping member 96, the clamping member 96 is driven axially toward the hub flange 16 such that the raised ribs 13 of cavities 133 and 135 emboss and deform the ends 4 of the spokes 2 to conform to raised ribs 13. A firm deformed engagement connection between the hub flange 16 and the spoke 2 is thus achieved.

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[0129] One such arrangement is well illustrated in FIG. 21a where the hub flange 16 includes through-cavities 128 through which the spokes 2 are assembled. When the spoke 2 is assembled in the direction of arrow 107 and located within the cavity 128, liquefied encapsulating material 130 is flowed to circumfuse and fill the clearance between the spoke 2 and the cavity 128. When the encapsulating material 130 solidifies, the spoke 2 is firmly anchored within the cavity 128 of the hub flange 16. Further, to provide a mechanical interlock with the encapsulating material 110, the internal surface of ~~The~~ the cavity 128 includes a knurled or threaded portion 126 and the external surface of the spoke 2 includes a threaded portion 64 constituting a configured portion 36. It should be noted that the threaded portion 126 of the cavity 128 and the knurled portion 36 of the spoke 2 have clearance and do not necessarily interlock with each other, but instead they are coupled to each other via the conforming encapsulating material 130. The spoke 2 in this figure is a duplex spoke 2 which includes structural portions 3a and 3b and is aligned to have a straight path through the encapsulated or engaged portion 18 and extending on both ends out to the rim 8 (not shown). This

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"straight through" spoke alignment eliminates the possibility for any distortion of the spoke 2 within the ~~encapsulated region~~ engaged portion 18.